Shielding upgrade for the section S05 – S06 of the SIS18 beam tunnel

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Introduction

Due to the activation of soil and ground water below and sideward of the section S05 – S06 of the SIS18 beam tunnel, measurements regarding radiation protection and limitation of soil activation have been reviewed to take necessary steps towards an additional shielding in the project of "Link Existing Facility" (GAF). Fig. 1 shows an overview of the current scheme.

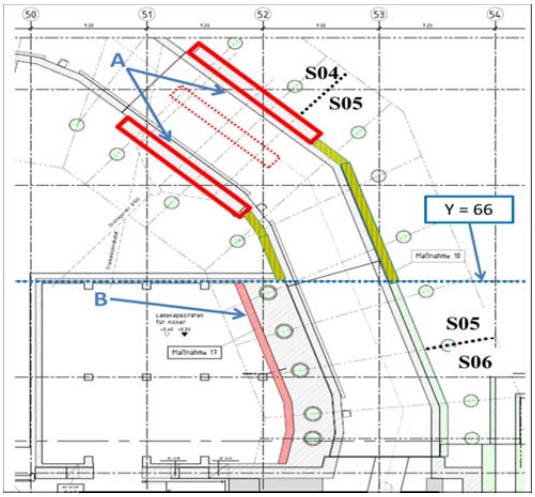

Fig. 1: S05 – S06 and its recommended additional shielding shaded in yellow. Existing shielding of the ESS is shown in red squares (point A) and, the dashed red square represents the assumed beam loss. The red shaded curve of 0.5m width (point B) illustrates the extra shielded east wall of the Kickerraum.

The dominant loss point is located at the Electrostatic Septum (ESS). In this region, where the beam loss rate is expected to be rather high, the existing tunnel is already shielded by 1.5m concrete (2.35 g/cm³, Fig. 1, red squares at the point A) in all directions. The wall on the east side of the so called "Kickerraum" is planned to be further expanded by 50cm of hematite concrete (4.6 g/cm³, Fig. 1 point B). The most critical part remains the region, where the additional ESS shielding ends – tangentially into the ground in the 0° direction of the beam – up to the transition of the S06, which, in turn, does not have an additional shielding.

Simulation

A simulation with the FLUKA [1] Monte Carlo code has been performed to estimate the activation levels due to beam losses. For the simulation, beams of protons (*p*, 4 GeV, 3% loss rate, $5 \cdot 10^{12}$ *p*/s) and Uranium ions (^{238}U, 1 GeV/u, 30% loss rate, $5 \cdot 10^{10}$ *U*/s) were used as input parameters for the calculation.

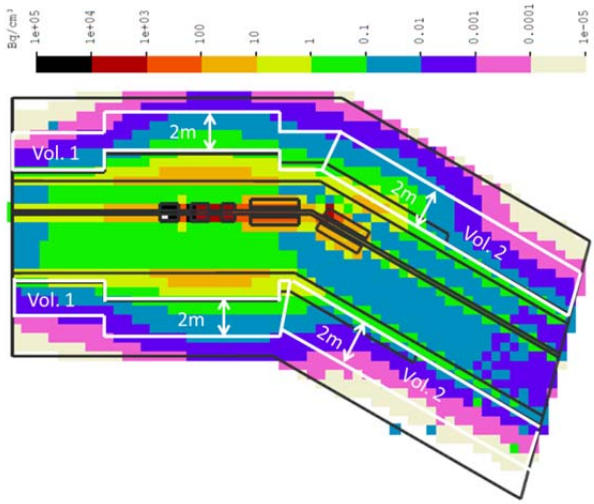

Fig. 2: Level of the activity concentration in units of Bq/cm³ calculated for an Uranium beam of 1 GeV/u and a loss rate of 30 % at the ESS of SIS18 beam tunnel.

Both scenarios were performed with an irradiation time of 4 years given by the time, in which the ground water flows – east to west – surveyed by evaluators as part of the construction license [2] for FAIR and, a cool down time of 10 years, in which the ground water is being transported. In order to find out the activity concentration of the soil, two defined volumes (Vol. 1 and Vol. 2, Fig. 2) of 1100m³ and 813m³, 2m wide on each side of the tunnel, were chosen respectively.

Results

An increased activation hotspot in the 0° direction of the beam, starting from the ESS directly into the soil on the outer part of the tunnel curvature, is clearly visible (Fig. 2). A comparison of these results with those calculated and documented in the FAIR application [3] shows that the activity concentration is an order of magnitude smaller than $7 \cdot 10^5$ Bq/m³ – the overall concentration of the soil around SIS18 mentioned in [3]. The local hotspot in Vol. 2 in front of the ESS (Fig. 2) is by a factor of 3 smaller than $7 \cdot 10^5$ Bq/m³. Comparing these results with threshold values of the German Radiation Protection Ordinance for unrestricted release, between 5% (whole S05 volume) and 40% (local hotspot) of the values allowed would be exploited.

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Conclusion

The results of the FLUKA simulations for beams of *p* and ^{238}U have shown that there is no need to strengthen the shielding of the whole region between S05 and S06. Although, due to strong radiation fields in the 0° direction and the activation of the ground environment, an extra and locally based reinforcement is required. A concrete wall of approx. 9m length and 0.5m thickness on the outer side up to at least Y-axis 66 (Fig. 1) and, a concrete wall of 0.5m thickness up to the Kickerraum on the inside part of the tunnel is recommended as an additional shielding (Fig. 1, drawn and shaded in yellow within S05).

References

[1] T.T. Böhlen, F. Cerutti, M.P.W. Chin, A. Fassò, A. Ferrari, P.G. Ortega, A. Mairani, P.R. Sala, G. Smirnov and V. Vlachoudis, "The FLUKA Code: Developments and Challenges for High Energy and Medical Applications", Nuclear Data Sheets 120, 2014, 211-214

[2] Antrag A – FAIR Gesamtantrag, Antrag auf Errichtung von FAIR gemäß §11 Abs. 1 Nr. 4 StrSchV

[3] Antrag A – Tektur 1, Anlage 23 (Antrag auf Errichtung von FAIR gemäß §11 Abs. 1 Nr. 4 StrSchV)

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